

## CONCERNING THE ANATOMY OF THE CORONARY ARTERIES.<sup>1</sup>

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FOR some time I have been engaged with experiments on the coronary arteries of the dog. As a preliminary a study was made of the anatomy of those arteries, the special object being to compare their distribution in the dog and man. What is here described is a fragment of the work, which is very similar to the anatomical study of the coronaries made in 1907 by Jamin and Merkel. While chiefly confirmatory of what they and others have shown it varies somewhat in details and for this reason as well as for the inherent interest and importance of the subject it seems to warrant a brief report. First, however, let me recall some previous observations of others that have important bearing on the problems connected with the coronary arteries.

Cohnheim and Schulthess-Reichberg<sup>2</sup> reported, in 1881, the first observations on the coronary arteries that aroused much interest. In their extensive experimental work on curarized dogs both ventricles stopped in diastole within two minutes following the clamping of either of the main branches of the left coronary artery. They concluded that the coronaries were end-arteries, and if anastomosis did exist it was by means of very fine capillaries.

Erichsen<sup>3</sup> had previously, in 1842, called attention to the relation of arteriosclerosis and angina pectoris. He was aware of the fact that in man the sudden occlusion of one of the large branches of the coronary arteries by a thrombus was a frequent cause of death, and he produced death experimentally in pithed dogs by the ligation of these vessels. Bezold and Breymann<sup>4</sup> verified these observations in their work on curarized rabbits. Cohnheim's conclusions were soon doubted. Investigators took up the problem from the side of animal experimentation as well as from anatomical study. Fenaglio and Draugnell,<sup>5</sup> in 1888, reported dogs which lived following the ligation of one of the large branches of the coronary arteries. Porter,<sup>6</sup> in 1894, had still more favorable results. He had dogs which lived for days following the ligation of one or two of the large

<sup>1</sup> Read before the Chicago Society of Internal Medicine.

<sup>2</sup> Ueber die Folgen der Kranzarterienverschliessung f. das Herz, Virchows Arch. f. path. Anat., 1881, lxxv, 503.

<sup>3</sup> Influence of the Coronary Circulation on the Action of the Heart, London Med. Gaz., 1842, ii, 561.

<sup>4</sup> Untersuchungen über die Herz und Gefässnerven der Säugethiere Untersuchungen a. d. physiol. Lab. zu Würzburg, 1867, i, 256.

<sup>5</sup> Cited by Herrick.

<sup>6</sup> Results of Ligation of the Coronary Arteries, Jour. Physiol., 1894, xv, 121-138.

branches of the coronary arteries. Miller and Matthews,<sup>7</sup> in 1909, further substantiated these observations. They reported a mortality of 8.7 per cent. following the ligation of the ramus circumflexus and no deaths following the ligation of the ramus descendens anterior of the left coronary artery as compared to Porter's results, who had a mortality of 88 per cent. following the ligation of the ramus descendens anterior. They concluded that the good results were due to the ether instead of curare and morphin as used by

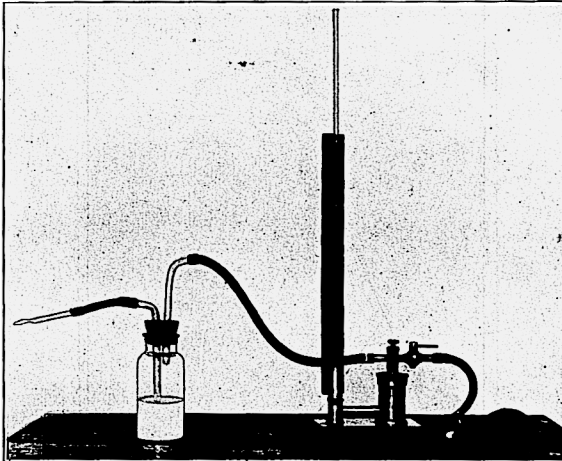


FIG. 1.—The apparatus used for injection of the coronary arteries.

Cohnheim, Fenaglio and Porter, and, furthermore, that there is an anastomosis between the branches of the right and left coronary arteries far greater than that suspected by Cohnheim.

Anatomical study threw still more light on the relationship of the coronary arteries. Amenomiya,<sup>8</sup> in 1907, demonstrated by injection methods subpericardial anastomosis in the hearts of young individuals. Hirsch and Spalteholz,<sup>9</sup> in the same year, showed an anastomosis of considerable size in the hearts made transparent following the injections of the coronaries with chrome yellow and

<sup>7</sup> Effects on the Heart of Experimental Obstruction of the Left Coronary Artery, *Arch. Int. Med.*, 1909, iii, 476-484.

<sup>8</sup> Ueber die Beziehungen zwischen Koronararterien und Papillarmuskeln in Herzen, *Virchows Arch. f. path. Anat.*, 1910, cx, cix, 187.

<sup>9</sup> Koronararterien und Herzmuskel: *Deutsch. med. Wchnschr.*, 1907, No. 20.

gelatin solution. Jamin and Markel<sup>10</sup> drew similar conclusions from stereoscopic skiagrams of hearts in which the arteries had been injected with wax containing iodoform.

Further evidence in favor of an anastomosis between the terminal branches of the coronary arteries is advanced by numerous autopsy observations which shows that the heart is often able to withstand the obstruction of a coronary artery or a large branch. James B.



FIG. 2.—The skiagram of a dog's heart in which the coronary arteries were injected with the barium mixture.

Herrick,<sup>11</sup> in an article on "Coronary Obstruction," cites autopsied cases reported by Merkel, Doch, West and others, including one of his own, in which various parts of the coronary system had been occluded by thrombi. In each instance the findings were indicative of an old lesion.

For a more extensive review of the literature on the coronary arteries the reader is referred to Porter,<sup>12</sup> Amenomiya<sup>13</sup> and Herrick.<sup>14</sup>

<sup>10</sup> Die Koronararterien des Menschlichen, Herzen in Stereoskopischen Röntgenbildern, Jena, 1907.

<sup>11</sup> Clinical Features of Sudden Obstruction of the Coronary Arteries, Jour. Am. Med. Assn., 1912, ix, 2015-2026.

<sup>12</sup> Loc. cit.

<sup>13</sup> Loc. cit. 4

<sup>14</sup> Loc. cit.

In the study of the coronary arteries the following technic was used: The heart within its pericardial sac was placed in the ice-box for twenty-four hours following death, so that *rigor mortis* might disappear. Cannulas were then introduced into the coronaries at their opening into the aorta and the heart infused with normal salt at 37° C. by means of apparatus shown in Fig. 1. The infusion was continued at a pressure which rarely exceeded 100 mm. Hg. in the dog and 150 mm. Hg. in man until the salt solution returned practically clear.

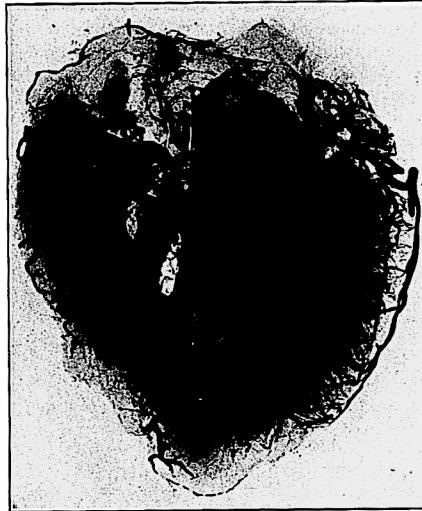


FIG. 3.—The injected heart of a man with marked fibrous myocarditis and sclerosis of the coronary arteries.

Following the infusion the coronary arteries were injected with a mixture of 2 parts barium and 10 parts water, to which was added a small amount of tragacanth to hold the metallic substance in suspension. This was injected at a pressure of 100 to 125 mm. Hg. in the dog and 125 to 150 mm. Hg. in man. Stereoscopic pictures were taken as soon as possible following the injection.

**OBSERVATIONS.** One could follow the course of the arteries with great ease after they were injected with the white metallic substance. This afforded an excellent opportunity to compare the coronary distribution in man with that in the dog.

By this method thirty hearts from dogs and twenty from man were studied. In all instances the arterial distribution in the dog and

man corresponded very closely. This similarity was also shown by the stereoscopic skiagrams. This is of importance, as it strengthens one in the belief that experimental results on the coronary arteries of the dog might be expected to be analogous to those in man.

During this comparative study of the coronary arteries of man and the dog, certain observations were made having a bearing on the question of anastomosis. When the hearts were infused the salt solution injected into one coronary artery escaped, drop by drop, from the cannula in the other coronary artery freely enough, so that



FIG. 4.—The injected heart of a young woman who died from pernicious anemia.

both arteries could be fairly well washed out by the infusion of one. This was noted both in the hearts of the dog and man. The salt solution could be seen entering the subpericardial distal branches of the ramus circumflexus sinister and the right coronary artery when injected into the ramus descendens sinister. I was also able to fill the distal branches of the right coronary and ramus circumflexus sinister with the barium mixture by injecting the ramus descendens anterior sinister with a pressure which did not exceed 100 to 125 mm. Hg. in the dog and 140 to 150 mm. Hg. in man.

The vascular richness of the cardiac muscle is perhaps better demonstrated by the stereoscopic skiagrams than by any other method. This vascularity seemed to be more marked in man than in the dog, as is shown in Figs. 2 and 4. These figures leave no doubt that there are anastomoses between the branches of the right and left coronary arteries. This is in most cases by means of many small vessels; only occasionally is one able to recognize an anastomosing vessel of any size.

This stereoscopic method shows nicely how the blood supply to the heart muscle may be markedly diminished by arteriosclerosis. Stereoscopic pictures were taken of hearts from patients varying in age from six months to sixty years. In some, which showed definite sclerosis of the aorta and coronary arteries, the number of small branches was markedly decreased, as shown by Fig. 3, from the heart of an old man showing marked fibrosis of the myocardium. In a case of this character it is easily understood how the occlusion of either of the larger branches by a thrombus would be more than likely to bring about death within a relatively short time. On the other hand the occlusion of one of the large branches shown in Fig. 4, where there is a rich network of unobstructed and anastomosing vessels, might, contrary to the view of some, particularly if the obstruction were gradual, be compatible with life.

**CONCLUSION.** 1. The distribution of the coronary arteries in the dog is practically the same as in man. Therefore, experimental studies of the coronary arteries in the dog will give a clearer conception of the pathology of these arteries in man.

2. There is an anastomosis between the branches of the right and left coronary arteries, which is, for the most part, by means of many small vessels, but distinctly numerous and large enough to functionate.

I wish to take this opportunity to express my appreciation to Dr. James B. Herrick for many helpful suggestions, to Dr. J. C. Rowntree, for his kindness in taking the skiagram and to the pathological departments of the Presbyterian and Cook County Hospitals.

### **FAT REDISTRIBUTION IN THE HYPOPHYSEAL TYPE OF DYSTROPHY ADIPOSEGENITALIS.<sup>1</sup>**

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THE function of the pituitary, like that of the thyroid, presides largely over growths, development and metabolism. The gonads

<sup>1</sup> Presented at a meeting of the Baltimore City Medical Society as a part of a symposium on Disturbances of the Internal Secretions.